TEXTILE RESEARCH

Publication of

United States Institute for Textile Research, Inc.

CHARLES H. CLARK, *Managing Editor,*

Publication Office: Prince and Lemon Sts., Lancaster, Pa.

Editorial and General Offices: 65 Franklin St., Boston, Mass.

Board of Editors

DR. W. E. EMLEY

PROF. L. A. OLNEY

PROF. E. R. SCHWARZ, *Chairman*

Publication Committee

WILLIAM W. BUFFUM

ERNEST N. HOOD

CHARLES H. CLARK, *Chairman*

Vol. VI **May, 1936** **No. 7**

CONTENTS

The Editor's Page 310

Textile Drying Conference 311

Warp Sizing Committee Reports on Progress and Plans ... 314

Experimental Studies in Flax Growing, Decorticating, Chemical Degumming, and Manufacture into Yarns and Papers (Concluded). *Textile Foundation Report* 316

Creep in Single Fibres of American Delta Cotton. R. L. Steinberger, *Fellow of the Textile Foundation* 325

Worth Cheering 330

An Optical Method for the Length Analysis of Cotton Fibres. K. L. Hertel and M. G. Zervigon 331

Abstracts 340

Entered as second-class matter, November 17, 1932, at the Post Office at Lancaster, Pa., under the Act of Congress of March 3, 1879.

Issued monthly at Prince and Lemon Streets, Lancaster, Pa., for United States Institute for Textile Research, Inc., Boston, Mass.

Made in United States of America.

Subscription price $5.00 a year. Single copies .50.

The Editor's Page

THE large number of reservations already received for the conference on textile drying problems, to be held at the Hotel Pennsylvania, New York, N. Y., May 6, under the auspices of U. S. Institute's Research Council, will insure a resultful meeting if discussion by those who attend is proportionate to their numbers.

IT can be predicted that there will emerge from the conference consciousness of the present lack and the dire need of scientific knowledge of drying temperatures that cause physical or chemical degradation of the different textile fibres and products of them: critical temperatures that are defined in terms of moisture content of material, time, relative humidity and volume of the circulated air, and other related factors.

THE misleading character of temperature readings as a guide to safe drying conditions must be evident to the manufacturer who gasses cotton yarns and cloths at flame temperatures, and to the finisher who dries cottons and rayons, treated with synthetic resins for crease resistance, at temperatures of 350° to 360° F., both without damage to the materials dried.

NOWHERE in the literature of textile drying and the theory of drying, thus far surveyed, are safe drying temperatures defined in relation to the other factors just named. It is not strange, therefore, that it is common practice to dry at much higher temperatures, nor that dyeing and finishing troubles are equally common. While accurate yardsticks for safe drying conditions might result frequently in increased dryer production, their greatest value would be in the elimination of dyeing and finishing damage due to improper drying. The bibliography of drying now in preparation will be published in the next issue, and will be available also to those attending the conference.

THE technique of practical textile manufacturing is based upon the experience accumulated over a period of 150 years by thousands of technicians throughout the world, and although this technique is now largely standardized, so-called secret methods are still hoarded. The active growth of scientific knowledge of textile fibres, products and processes started during the world war, has been developed in an organized manner in this and several foreign countries for little more than a decade, and most of the findings of scientific textile research are ultimately made available internationally. Thus unnecessary duplication of effort is avoided, and the accumulation of new fundamental knowledge is relatively rapid. If all research organizations throughout the world were as generous as the Technological Laboratory of the Indian Central Cotton Committee in making public the results of their scientific studies, the progress in scientific textile research would be even more rapid than heretofore. In "Cotton Research in India 1924–'35" Director Nazir Ahmad describes the work accomplished

by this laboratory, including very complete abstracts of a large number of researches on cotton fibres and yarns, and lists the prices at which complete copies of these and other reports are available.

THE large, handsome and well-equipped buildings housing the research and spinning laboratories of the Indian Central Cotton Committee, as illustrated in "Cotton Research in India," a book reviewed in this issue, are an example of the exceptional facilities provided by certain foreign governments for fibre and other textile research; additional examples being in the U. S. S. R. and Great Britain. A survey of the operating policies of these foreign textile laboratories will demonstrate, however, that it is not their buildings and equipment that are a just cause for our jealousy, but the fact that these government-financed laboratories serve equally and directly both the growers of fibres and their manufacturers, and that their work is much more closely co-ordinated than government research in this country. Fortunately, our manufacturers have available the outstanding research facilities and services of the National Bureau of Standards, and indirectly, of course, they benefit from the unco-ordinated work of Department of Agriculture laboratories.

Textile Drying Conference

THE conference on textile drying problems to be held at the Hotel Pennsylvania, New York, N. Y., Wednesday, May 6, under the auspices of U. S. Institute's Research Council, will be open to all who are interested in the subject, whether or not they are members of U. S. Institute. Following brief introductory papers the discussion will be open to all in attendance. In order to stimulate the freest possible interchange of experience and facts, those who prefer not to be quoted by name will have their wishes respected in the stenographic report. A registration fee of $2.00 will entitle the bearer to luncheon and a copy of the stenographic report of the proceedings.

Program

Warren E. Emley, chairman of the Research Council, and chief, Organic and Fibrous Materials Div. of the National Bureau of Standards, will preside. The first session will open at 10:30 A.M.; luncheon will be served at 12:30 P.M., and the conference will reconvene at 1:30 P.M. At the morning session, papers opening the discussion of the various sections of the subject will be presented by the following:

Cotton.—Samuel B. Bird, Joseph Bancroft & Sons Co.
Wool.—E. N. Angus, Eavenson & Levering Co.
Rayon.—Dr. F. Bonnet, The Viscose Co.
Silk.—Erb N. Ditton, Gotham Silk Hosiery Co.
Drying Machinery.—James T. Hunter, James Hunter Machine Co., and Lucien Buck, Proctor & Schwartz, Inc.

Purpose

The purpose of the open conference is to learn whether there is anything connected with textile drying problems which needs scientific research

for its solution and correction, and that is likely to produce worthwhile results. The open conference, by which the practical experience of technicians and the basic knowledge of scientists is made available to those who attend, is the usual method by which U. S. Institute for Textile Research attempts to obtain this information. Of three previous open conferences held by U. S. Institute, two resulted in research projects, and one indicated that the subject (wear testing) was not adapted for general study. Attendance at these conferences ranged from 100 to 250.

Damage and Loss

The subject of drying has been on the Research Council's tentative list of research subjects for some time. Disclosure by U. S. Institute's warp sizing study of the wide variation in temperatures that are being used by different mills for the drying of sized warps caused the Council to place the subject on the active list at their recent meeting in Washington, D. C. It needed but brief discussion at that meeting to prove that equally wide temperature variations exist in the drying of practically all textile materials, that temperatures so high as to cause serious damage to the dried material are common, that they are frequently due to the urge for increased production and lower drying cost, and to deplorable neglect of the fact that the "hand," strength, and dyeing and finishing qualities of textile materials that have been damaged by excessive heat can never be restored.

It was also indicated at that meeting that some manufacturers, by scientific study of their drying problems, have greatly improved the quality of their dried product when dyed and finished, with reduction in costs of the latter processes, and sometimes of drying costs. The experiences of some of these manufacturers will be explained at the coming conference.

Meaningless "Safe Temperatures"

Unfortunately, much of the damage in the drying of textile materials can be traced to the fact that the so-called "safe drying temperature limits" are accepted in too many instances without consideration of their relation to time of drying, moisture content or regain of material, relative humidity and volume of the circulated air, and in can-drying to the temperature of the steam or the condensed water in the cans instead of that of the outside surface of the cans.

Unless drying temperatures are correlated with these important factors of the drying process they are meaningless and dangerous. Unfortunately, the literature of textile drying contains little reliable scientific data of this character. Textile drying, like much other textile processing, is conducted empirically—on the basis of experience. This may afford reasonably safe procedure for the drying of some one material, but not necessarily the cheapest or most efficient method; and it affords no safe guide to the efficient drying of other materials.

Economic Factors

This very complicated problem is further complicated by its economic factors—drying production and costs; not only cost of drying, but cost of materials. Were there exact scientific knowledge of safe drying conditions

within certain tolerances it might be possible to increase production limits now considered safe maximums, or they might have to be reduced. Drying damage to cheap cottons, that might not become apparent until the products were dyed and finished, is one thing; similar damage to rayons, silks, woolens or worsteds is a more serious matter financially. There are no statistics showing the annual losses in dollars and cents due to inefficient textile drying, but no statistics are needed to prove that the losses due to dyeing and finishing troubles, to yarn and fabric strength, and to the desired "hand" or feel of the finished fabric, for which it is responsible, are tremendous.

This is but a brief and incomplete outline of the reasons for giving those members of the industry, who are interested in improving drying methods and results, an opportunity through this conference of securing reliable existing information on drying, and of learning through open discussion whether scientific research of any feature or features of drying is needed and is likely to produce valuable practical results.

Report of Conference

An outline report of the conference, including a selected reference list of books and articles on the subject of textile drying, will be published in the next issue of this magazine. Those desiring a complete stenographic report of the papers and proceedings may obtain it by forwarding check for $1.00 to C. H. Clark, Secretary, U. S. Institute for Textile Research, Inc., 65 Franklin St., Boston, Mass.

Obituary

Albert Farwell Bemis, an original member of U. S. Institute, a former president of the National Association of Cotton Manufacturers, and prominently connected with the textile industry since his graduation from Massachusetts Institute of Technology in 1893, principally with the Bemis Bros. Bag Co., of which he was president from 1909 to 1925 and then chairman until 1934 when he retired, died in a Phoenix, Arizona, hospital April 11. He had been on a trip to the Pacific coast, accompanied by his wife. He was born in Newton, Mass., Nov. 11, 1870, and had always resided there. Throughout his career he gave generously of his ability and money in associational, educational and charitable work. He had been a life member of the corporation of M. I. T. since 1914, and had been active in its affairs. A vocation and an avocation of his later years was the field of housing, and his authoritative knowledge of the subject is shown by his three-volume work "The Evolving House," the last volume of which was completed only recently. He is survived by his wife and seven children.

Warp Sizing Committee Reports on Progress and Plans*

By WRIGHT BOLTON, Chairman

FOLLOWING a study of the rather meagre literature of starches as sizing materials, the committee administering the warp sizing study of U. S. Institute for Textile Research, has accumulated as a result of several months of laboratory work, a substantial amount of basic data, much of which is new, or that defines the sizing value of previously known properties of starches. The results of this work are covered in three progress reports, two of which have already been received by co-operators. The third report will go forward shortly. Most of this initial research work has been confined to 1% starch solutions, whereas practical sizing involves the use of concentrated solutions.

An attempt must be made to correlate results obtained from 1% solutions with concentrated solutions. Normally this would be the next step, but the committee has decided that this should be delayed until they, and those in direct charge of the research work, may have the benefit of the practical experience of mills with the radically new slashing machinery that has been in process of development since this study started.

The higher speeds and higher temperatures indicated for these new slashers seem entirely practical, and throw the whole situation into a state of flux. As there seems to be a definite relation between the starches and their viscosities and the time and the temperature essential for efficient sizing, it is not at all impossible that new lines of experimental research in actual sizing operations will be indicated. This work on concentrated starch solutions for sizing, will, therefore, be delayed, and work will be undertaken meantime on glues, gelatines and other materials for the sizing of synthetic yarn warps.

It should be clearly understood that, when work is again resumed on starches and starch sizing, an attempt will be made to interpret work already done in terms relating to practical sizing problems. It is clearly understood that the application of sizing materials to textile fibres is a rather broad and complicated subject, and that the requirements are different for such groups of fabrics as sheetings, print cloths, fine-count cottons, colored goods, woolens and worsteds. In applying the results of the preliminary studies to each group the fabrication requirements of each will be given careful consideration.

The study of warp sizing of synthetic yarns and of the materials used in this connection will be along somewhat different lines than those followed thus far in the study of starches and starch sizing. There will be only a brief preliminary study of the literature, and of the properties of the sizing

* Report of Warp Sizing Administration Committee presented to Board of Directors, March 11, 1936.

materials, and it will then be transferred to experimental research on actual sizing under mill conditions. This experimental research will be conducted on machines and yarns, and with methods and sizing materials that have been adopted as standards for this study, and that are believed to represent most efficient practice. It is believed that results having practical application can be obtained in this way in the shortest time, and that they will define accurately the problems involved that must be subjected to basic research in the laboratory.

For justification of the different research methods first employed and those that are to be followed in synthetic yarn warp sizing, it must be remembered that cotton and worsted sizing methods and materials have been on a relatively standardized basis for a long period. The "hows" of doing a relatively satisfactory job are well known; the unknown factors are the "whys," and the latter were so plainly indicated that basic research could be started without preliminary mill experimentation. In the case of warp sizing of synthetic yarns neither the "hows" nor the "whys" are as clearly standardized or defined. Therefore the approach to the latter by experimental research in the mill, including processes preparatory to warp sizing, and the weaving, desizing and finishing processes.

Preliminary to the starting of this study, and for the purpose of planning the details of this experimental research along scientific and practical lines, a meeting of authorities on the various subjects involved was held at Massachusetts Institute of Technology, Feb. 1. In attendance also were the director of the study and his assistants. Among those who kindly offered their advice were the following: Dr. S. E. Sheppard, Eastman Kodak Co.; Dr. F. Bonnet, Viscose Company; Dr. H. DeW. Smith, Tennessee Eastman Co.; Prof. A. H. Grimshaw, North Carolina State College; Mr. West, Draper Corp.; Mr. Palmer, Crompton & Knowles Loom Works; Dr. J. R. Katz; Prof. E. R. Schwarz of M. I. T., and my committee associates, Dr. J. B. Quig, Du Pont Rayon Co., and Dr. H. A. Neville, Lehigh University.

Standards of procedure for carrying out the work were discussed and adopted at this meeting. Viscose warps will be the first subject of experimentation, and acetate warps will be studied later. Since that meeting, laboratory work on materials, that was then indicated to be necessary, has been in progress, and it is expected that the experimental research in the mill can be started at a very near date.

"Out in the western part of the country, from which I have just come, I was told of two very recent happenings which suggest research in other fields than science into their causes. A certain company which had some excavating to do was asked not to do it with its steam shovels but rather to let men who needed work do it by hand. The same company in order to start up new work advertised for five hundred new employees and after two weeks of waiting had received eighty-one applicants, though there are thousands upon thousands in the State on the relief rolls. Does this suggest that science is the cause of all our unemployment as so many voices are shouting now-a-days?" From Address of Dr. Robert A. Millikan to U. S. Institute, Nov. 14, 1935.

Experimental Studies in Flax Growing, Decorticating, Chemical Degumming, and Manufacture into Yarns and Papers

(Continued from V. VI, No. 6)

Part III. Spinning of Flax Fibre (Crop of 1934)

By H. H. WILLIS

A Textile Foundation Report

VARIOUS spinning tests were made on the flax fibre processed under the new method. As was described in Part II preceding, two methods of mechanical decorticating and several methods of chemical degumming were used in preparing the fibre for these manufacturing tests. As described in Part I, the experimental flax was grown under different but known conditions.

These manufacturing tests were thorough and varied. Fibre from water-retted as well as from unretted flax was used experimentally. Both 100% flax and flax mixed with cotton in different proportions were tried out on various types of spinning equipment. Different machine organizations and settings were used. Tests were made at various places and on various lengths of flax fibre.

Section 1—Manufacturing Tests (100% Flax)

Nine different manufacturing tests of 100% flax from various sources, some of which was water-retted and some decorticated and chemically degummed, are described in Section 1 of Part III, and in every case, whether processed on the cotton or the woolen system and cut to the required lengths for each, the rovings either could not be spun or end breakage made spinning costs prohibitive. The chemical degumming was that described in Part II as No. 4; for scutching and decorticating, Machine B was used. In each experiment of this series the fibres were badly broken on the card and the card product was extremely uneven, lumpy and contained much shive. Figs. 3, 4, 5 and 6 illustrate conditions rendering spinning difficult or impossible. For these reasons descriptions of these particular experiments are omitted in this outline of the report. The manufacturing tests on flax and cotton mixtures were somewhat more successful and follow.—Editor.

Section 2—Manufacturing Tests (Flax and Cotton Mixtures)

(A) *Lot 16, Unretted Flax (50%) and Cotton (50%) Mixture, Woolen Waste Card, LaGrange, Ga.*—The next test (Lot 16) tried at LaGrange was a mix of unretted flax fibre, decorticated by Machine B, degummed by experiment No. 4, and cut 1-inch long, with an equal amount of 1-inch cotton. The cotton was opened by hand and mixed by hand with the flax. The running of the work would probably have been improved if mixing had been done mechanically. This mixture was fed into the hopper of the breaker card. A finisher card with tape doffer was used. This mix ran well on the cards, the ends staying up very well in front. The sliver gave no trouble going over the Scotch feed to the finisher. Four good jack spools were made and one was run on the Whitin Pease spinning. It ran well on the spinning. Eighteen spindles were run for almost a complete doff. The yarn was tested at Clemson. Table 1 records the average results of the strength and size tests. Fig. 8 shows these results graphically.

(B) *Lot 17, Unretted Flax (75%) and Cotton (25%) Mixture, Woolen Waste Card, La Grange, Ga.*—Another experiment (Lot 17) tried at LaGrange, Ga., was mixing 75% unretted flax fibre decorticated by Machine B, degummed by experiment No. 4 and cut 1-inch in length, with 25% cotton. With this mix it was possible to run the jack spools on the card and spin them but they did not run as well as the 50–50 mix. In the opinion of those at the mill this mix might possibly be used for filling yarns. However, the high end breakage on both card and spinning would make labor cost on it high. Probably better mixing and some change of speeds and settings would improve the running of this mix. One doff of 18 bobbins was run. The yarn was tested at Clemson for size and strength. (See Table 1, Fig. 8.)

TABLE 1

Average breaking strength and size of mixtures of unretted flax and cotton.

Lot	Mix	Strength Lbs.	Size (Cotton Count)
16	50% Flax 50% Cotton	173.82	4.59
17	75% Flax 25% Cotton	123.94	3.87

This 50–50 yarn shows a weaker comparative breaking strength than that of a similar cotton and flax mixture spun on regular cotton machinery, but the manufacturing cost on the woolen waste system should be less than on cotton equipment.

(C) *Lot 18, Water-Retted Flax (50%) and Cotton (50%) Mixture, Cotton Equipment, Clemson, S. C.*—The water-retted flax straw (Lot 18) used in this test was grown at Swannanoa, N. C., and was scutched by Machine B. It was retted for seven days in a concrete pool at Clemson,

in August, 1934. A slow flow of water went through the pool continuously. This water-retted flax fibre, cut 1-inch in length, was run five times through a two-blade cotton finisher picker in an effort to open and clean the fibres. It ran fairly well on the picker, although the lap showed some tendency to split. This lap was run on a Saco-Pettee card covered with Platt's metallic clothing. The web was not run into a sliver but allowed to fall down from the doffer comb. The carding split up the fibres and cleaned out most of the shive.

This carded flax was then taken back to the picker room and mixed half and half with 1-inch cotton. This mix ran into a very good picker lap which ran off evenly on the card. The mixture was carded on the same card, with the same speeds and settings as had been used on the flax before mixing. The web ran very well. A fairly even sliver, yard for yard, was delivered but it had heavy and light places in it for shorter lengths. This sliver was run through two roving processes. It ran very well on the roving frames with a high twist, but the roving was somewhat uneven. This roving was then spun into 10s and 15s yarn under the same conditions as Lot 19, described in the following paragraph D. (See Table 2 and Fig. 8 for test data.)

(D) *Lot 19, A. T. Johnson Unretted Flax (50%) and Cotton (50%) Mixture, Cotton Equipment, Clemson, S. C.*—The straw used in this test (Lot 19) was grown by A. T. Johnson at Concord Wharf, Va. It was decorticated by Machine B and degummed by experiment No. 4. The fibre was cut three inches long. It was run through a two-blade finisher picker three times to split and open up the fibres and remove the shive. It was then mixed half and half with the same kind of 1-inch cotton with which the Swannanoa water-retted flax had been mixed. This made a fair picker lap which ran satisfactorily. This lap was run on a Saco-Pettee cotton card with Platt's metallic clothing. The card web ran fairly well on this mix but it was full of lumps and cloudy places. When the mix had been processed thus far, it was found that the three-inch flax fibres had broken up until they were no longer than the fibres of the 1-inch cotton with which they were mixed. The drawing and roving frame rolls were set for 1-inch staple. The card sliver and first drawing sliver were very uneven. The second drawing sliver was less uneven. This sliver was then passed through two roving processes. This Lot 19 and Lot 18 (listed under preceding heading (C)) were spun under as nearly the same conditions as possible with a view to some general comparison between water-retted and chemically degummed fibre.

The chemically treated fibre retained considerable shive and long, coarse fibre. A quantity of such small pieces of shive and fibre fell out on the spinning guides as the yarn was being twisted. (See Fig. 6.) This trash caused extra end breakage on spinning.

The first spinning frame used on this Lot 19 was a Saco-Lowell frame with long-draft rolls. The yarn numbers spun on this frame were 10s and 15s from each lot. With the high twist necessary, the front roll speed was considerably below normal for both 10s and 15s cotton yarns. Both lots were then run on a Saco-Pettee spinning frame, regular draft, making 10s and 6s yarns with twist as low as practical. With the high twist used, the front roll speed was below normal for cotton yarns on these numbers. (See Table 2 and Fig. 8 for yarn strengths.)

TABLE 2

Strength per skein of yarns spun on cotton equipment from flax and cotton mixtures at Clemson, S. C.

Lot and mix	Yarn numbers		
	6s Pounds	10s Pounds	15s Pounds
Lot 18, mix of cotton (50%) and water-retted flax (50%)	196.3	118.4	67.5
Lot 19, mix of cotton (50%) and A. T. Johnson unretted flax (50%) [1]	186.7	110.0	63.4

[1] Flax degummed by experiment No. 4.

Table 2 indicates that the yarns spun from a 50–50 mixture of cotton and water-retted flax scutched by Machine B were somewhat stronger than those spun from a 50–50 mixture of cotton and A. T. Johnson unretted flax decorticated by Machine B and degummed by experiment No. 4.

Section 3—Manufacturing Tests (Lot 20)

(*Lot 20*) *Clemson Unretted Flax, Various Tests, Cotton Equipment, Clemson, S. C.*—Lot 20 was grown at Clemson S. C. Portions of this unretted lot, cut in two lengths, were tested in various ways on cotton manufacturing equipment. The 100% flax was used in some cases, and in other cases this flax was mixed with cotton in equal amounts. The fibre of Lot 20, decorticated by Machine B and degummed by experiment No. 4 both appeared and tested stronger than the A. T. Johnson fibre similarly treated. This Lot 20 was subjected to more tests than any other one lot, because it appeared to be the most promising sample of chemical degumming.

A. (*Lot 20*) *100% Unretted Flax, Cut Three Inches.*—This fibre was run into a picker lap and tried on a Saco-Pettee cotton card with different licker-in speeds and flat settings. The flax fibres tore up badly and the web would not run. This test was therefore discontinued.

B. (*Lot 20*) *Unretted Flax (50%), Cut Three Inches, and Cotton (50%).*—The balance of the picker lap run under A preceding was taken back to the picker room, mixed with an equal part of 1-inch cotton, and run through the finisher picker. This lap was run on the card without difficulty. Some of it was run through two drawings, some through no drawings, and some spun from double creel intermediate roving and some from single creel slubber roving. See Flow Sheet, Fig. 7.

C. (*Lot 20*) *100% Unretted Flax, Cut One Inch.*—Another portion of Lot 20 was cut 1-inch in length and was run through the finisher picker three times. This 100% flax lap was tried on the same card as the three-inch flax fiber (A above), but would not run.

D. (*Lot 20*) *Unretted Flax (50%), Cut One Inch, and Cotton (50%).*

—The balance of this lap of 1-inch flax run under C preceding was taken back to the picker room and mixed with an equal amount of 1-inch cotton. It was run through the finisher picker twice to give a good mix. See Flow Sheet, Fig. 7.

These two lots of mixed flax and cotton (B and D) ran fairly well on the cards, drawing and roving frames. The drawing sliver, however, did not draft properly. It was full of lumps of short fibres which showed up in the roving and yarn. A high twist was necessary on the roving frames to make the roving run and pull out of the creel on the next process. It was necessary to put additional weight on the rolls in the spinning to improve the drafting of the fibres.

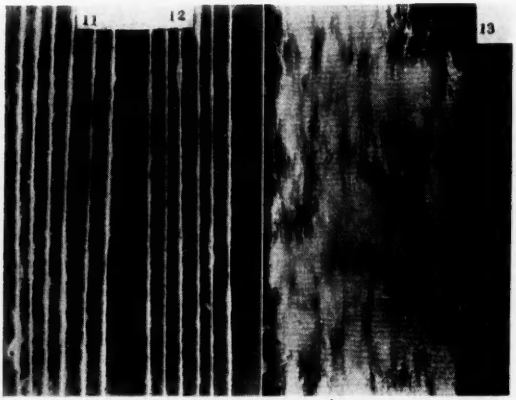

FIG. 3. FIG. 4.

FIG. 3.—Showing uneven roving. Section 11 is 100% Swannanoa flax degummed at Clemson, S. C. Section 12 is a mix of 50% 1-inch cotton and 50% A. T. Johnson flax degummed by experiment No. 4.

FIG. 4.—Web of 100% unretted flax from the cotton drawing frame. This flax had been decorticated by Machine B and degummed by experiment No. 4, after which it was run through a Whitin woolen waste card at LaGrange, Ga., and then through a cotton drawing frame at Clemson, S. C. Note thick and thin places in the web.

Flow Sheet, Fig. 7, presents graphically the various treatments of the 50–50 mix of unretted flax (Lot 20) with cotton. Fig. 8 gives the size and breaking strength of the various yarns spun from this 50–50 mix. Fig. 8 indicates that the 10s and 15s yarns spun from 1-inch unretted flax of Lot 20 mixed half and half with 1-inch cotton and run through two drawings and double creel roving were stronger than any of the other yarns. These yarns also ran better on the spinning. It would be necessary to run further tests on each yarn in order to determine the amount of twist which would produce the best running and the best breaking strength.

Summary

Carding and Spinning of 100% Flax

In these particular tests the spinning of the 100% flax was a failure on the three types of equipment used, i.e., cotton, woolen, and woolen waste systems.

The fibres of the water-retted flax and of the unretted flax, degummed by experiments Nos. 1 and 2 listed in Part II of this report, were strong enough to be spun, but no method was devised to split the fibres to a diameter sufficiently fine and uniform to be run on the types of equipment used.

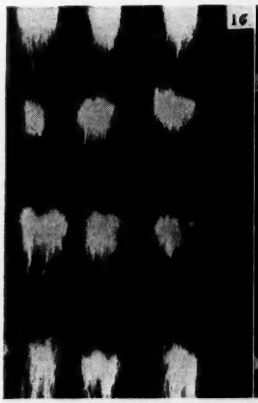

Fig. 5.

Fig. 6.

Fig. 5.—Lumps of fibre taken from the drawing web of 100% unretted flax shown in Fig. 4. Note the unevenness of staple length.

Fig. 6.—Short fibre and shive which accumulated on the guide board of the spinning frame, as the yarn was being twisted in spinning. The illustration shown is from a mixture of 50% cotton and 50% unretted flax decorticated by Machine B and degummed by experiment No. 4. It was spun on the cotton system. Note the long, coarse flax fibres which go through to the spinning.

Woolen waste equipment.—When the 100% unretted flax fibre, decorticated by Machine B and degummed by experiment No. 4, was tried on a woolen waste card, the flax fibres three inches in length crossed over in the rub apron and tore down the adjoining ends; therefore the 100% flax would not run. The flax cut 1-inch in length was not strong enough to run from the rub apron to the jack spools.

Cotton equipment.—The fibres of the 100% unretted flax, decorticated by Machine B and degummed by experiment No. 4, had very little strength when run through a cotton card. The majority of the fibres broke up so

badly and were so short that the web on the card could not be run into a sliver.

When the sliver made on the woolen waste card at LaGrange, Ga., was tried out on the cotton drawing frame at Clemson, it would not draft evenly. The web on the drawing frame was irregular and lumpy and broke

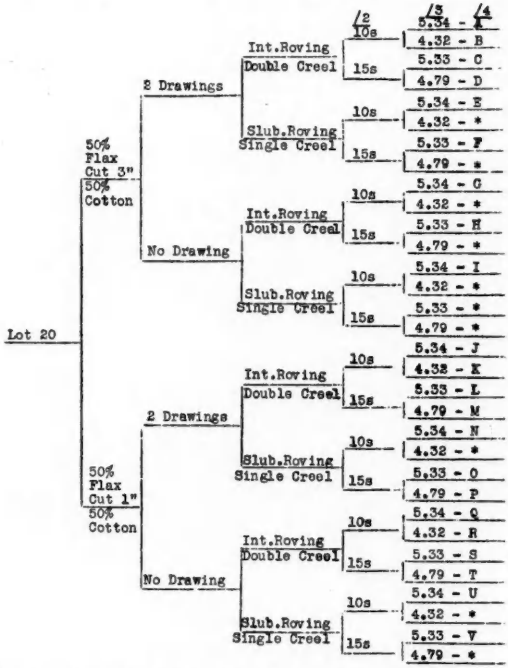

FIG. 7.—Flow sheet showing the different cotton manufacturing processes through which a 50–50 mix of cotton and flax was passed. The flax (Lot 20) was subdivided into several portions, each of which was then mixed with an equal amount of cotton.[1]

[1] See Fig. 8 for strengths of yarns.
[2] The yarn number spun is indicated in this column.
[3] The twist multiplier used is listed in this column.
[4] The letters represent subdivisions of Lot 20.
* Would not spin.

down between the trumpet and the calender roll. Fig. 4 shows the web from a cotton drawing frame of 100% unretted flax degummed by experiment No. 4 and run into sliver on a Whitin woolen waste card. Fig. 5 shows lumps of fibre taken from the web shown in Fig. 4. These fibres were pulled out as in stapling cotton. Note the unevenness of staple length.

Carding and Spinning of Flax and Cotton Mixtures

Woolen waste equipment.—Unretted flax, decorticated by Machine B, degummed by experiment No. 4, and cut 1-inch in length, was mixed with an equal amount of 1-inch cotton and run on the woolen waste system at LaGrange, Ga. This mix ran well and in the opinion of those familiar with the woolen waste system could probably be used for warp or filling yarns.

These yarns, however, were not so strong as were those manufactured from the same mix on the cotton system. The 10s yarn spun on cotton equipment from a mixture of 50% unretted flax and 50% cotton broke 160 pounds whereas the 4.5s yarn of the same mix spun on the woolen waste system broke 173 pounds. In comparison, the yarn spun on the cotton

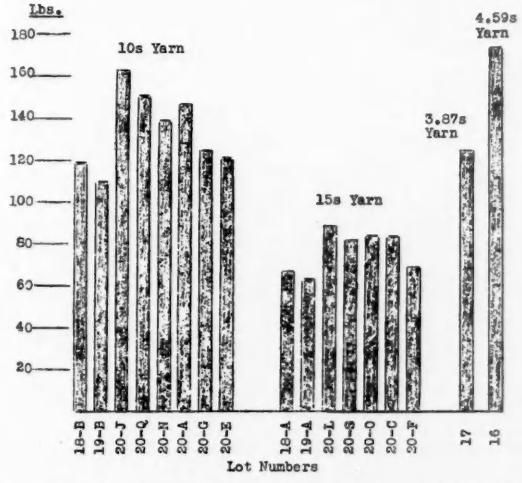

FIG. 8.—Strengths per skein of yarns spun from flax and cotton mixtures. The yarns in Lots 16 and 17 were spun on woolen waste equipment. The yarns in Lots 18 to 20 inclusive were spun on cotton equipment.

system was stronger. Some of the unretted flax decorticated by Machine B, degummed by experiment No. 4, and cut 1-inch in length, was mixed with cotton, in the proportion of 75 to 25%, and run on the woolen waste system. This mix ran very poorly but could be spun into approximately 4s filling yarns. However, on account of the excessive end breakage, the labor cost would be high.

Cotton equipment.—Water-retted flax was mixed in equal parts with 1-inch cotton. Flax degummed by experiment No. 4 was also mixed half and half with 1-inch cotton. Both of these mixtures were spun in yarn numbers up to 15s. The unretted flax of Lot 20 decorticated by Machine B, degummed by experiment No. 4, and cut 1-inch in length, showed an

average skein break on 15s yarn with a 4.79 twist multiplier of 94 pounds, while the average skein break of the 10s yarn with a 4.32 twist multiplier was 160 pounds. Both these yarn numbers ran very well. However, their running could probably be improved by further experiment with roll settings and twist. Some shive and considerable coarse fibre were retained throughout the carding process and interfered with the spinning.

The cotton (50%) mixed with unretted flax (50%) of Lot 20, decorticated by Machine B and degummed by experiment No. 4, ran better and produced stronger yarns than the 50–50 mixture of cotton and water-retted flax.

Findings based on manufacturing tests.—The 100% chemically degummed flax of these tests would spin neither on the cotton equipment nor on the woolen waste equipment used in the tests. Future improvements in decorticating or in chemical degumming or in both may make it possible to spin 100% flax on these types of equipment satisfactorily.

A mixture in equal parts of chemically degummed flax with cotton spun fairly well on both the cotton or the woolen waste systems, such mixed yarns being spun on cotton equipment in numbers through 15s, and through 4.5s on the woolen waste system.

A mixture of chemically degummed flax (75%) with cotton (25%) was spun on woolen waste equipment in yarn numbers up to 4s, but the labor cost was high.

The yarn spun on the cotton system showed the better breaking strength. However, the manufacturing cost on yarn numbers that can be spun on either system is less on woolen waste equipment than on cotton equipment.

Fabrics woven.—Yarns made of a mixture of flax and cotton were used as filling in weaving mixed fabrics.

"*IN a civilisation such as ours there is no escape from the conclusion that any industry which does not rest on sound scientific principles must ultimately die. The day is gone beyond recall when we may do things just simply hoping for the best. We must know exactly why we are doing them, as far as the utmost resources of science can tell us, so that we may control our manufacturing materials and not they us. Can we say that we have every process under strict control? We know too well that we cannot, and perhaps it is too much to ask this. But can we even say that we have our processes under such an amount of control as the available scientific knowledge permits? Again we must confess that the answer is 'No.' There needs much closer co-operation between scientist and technologist than exists today.*"—W. T. Astbury in "Fundamentals of Fibre Structure."

Creep in Single Fibres of American Delta Cotton

By R. L. STEINBERGER *

Fellow of the Textile Foundation

Abstract

The constant stress elongation or creep of single filaments of American Delta cotton, crop of 1935–36, has been measured at relative humidities ranging from 0% to 100% and at a temperature of 28° C. The cotton is similar to the rayons of the cuprammonium and acetate types in that for certain ranges the extension $e = k \log t + c$, but the constant k tends towards smaller values with increasing time, while in the acetate rayon the reverse is true.

Introduction

IN the testing of the mechanical properties of single cotton filaments accurate quantitative results are not to be expected because of the haphazard gross structure and fineness of the fibre. Gross or macroscopic structure means here the external mechanical structure as revealed by low power magnification. The filaments are hollow, that is, they possess a lumen the cross-section of which varies from fibre to fibre. Under ordinary conditions of relative humidity (R. H.) the filament is a flattened and twisted ribbon with, in general, greater flatness and more twists per inch the lower the R. H. However, there is no unique relation between twist or flatness and R. H. The filaments are quite short from the standpoint of convenience of handling (staple 1 3/16″) and, to make matters worse, taper toward one end. For assurance of reasonable constancy of section in the tension specimen the tapering end must be cut off. This means a reduction of about one-third in specimen length. Considerable kinkiness makes it impossible to get an accurate zero length (Lo) for zero load. For the same reason the first elongation reading taken after application of load in the creep tests is subject to considerable uncertainty.

It is not intended that this enumeration of external irregularities has a bearing on the internal crystalline or micellar arrangement. There is considerable evidence to show that the internal structure has a high degree of regularity and symmetry. At the other extreme from the cotton fibres lie the synthetic textile filaments, characterized by great external uniformity coupled with irregular crystalline or micellar internal structure. The peculiar and valuable behavior of cotton as a textile fibre is certainly in

* Dr. Steinberger is working under the direction of Prof. P. W. Bridgman, Harvard University, Cambridge, Mass.

large measure due to the contrasting aspect of external and internal structure. The external irregularity enhances fibre interlocking and leads to fine and even spinning, while the regular internal structure leads to great strength and relative freedom from changes in strength due to water vapor and other mild reagents.

The present measurements on creep in cotton must be regarded as exploratory, the principle aim being to make preliminary comparisons between the behavior of cotton and of the acetate and cuprammonium filaments already studied.[1, 2]

Measurement Details

Most of the details of technique have already been described.[1, 2] The character of the stress-strain curve for Egyptian cotton,[3] indicates that for cotton in general the creep will be small because the curve is accurately linear right up to the point of rupture, with no evidence of plastic yield. If creep is present it will be greatest and most easily measured at stresses near the rupture stress. The Egyptian cotton fibre broke at about 27 kg/mm^2. A round figure of 25 kg/mm^2 was chosen for the tension stress in the present tests. Thus for measurable creep a stress nearly four times that imposed on the acetate and cuprammonium filaments is indicated.[1, 2]

Variation in fineness from fibre to fibre makes imperative some attempt at cross-section measurement on each filament tested. The rigorous procedure is to mount the fibre, section it with a microtome and measure the area of the cross-section under the microscope. Past experience indicates that to do so would involve more time than is wise until after some results are obtained showing the trend of the phenomena. A compromise was adopted. The selected fibre was attached to a microscope slide by a slip of scotch tape at each end. The cotton filament was then examined carefully under the microscope until a region was discovered where the ribbon form was regular and smooth across most of the field of view, and until the ribbon made one complete and well-defined 180° twist with the narrow or edge-on width of the ribbon at the center of the field of view. A camera-lucida drawing was then made of the twisted ribbon. The maximum and minimum ribbon widths were measured on the drawing.

To compute the section area two assumptions were made: one that the true external section perimeter is an ellipse with axes equal to the maximum and minimum ribbon widths; the other that the lumen section is a constant fraction of the total section area and may be taken as zero for comparison purposes. Assuming the lumen section area to be zero leads to an applied stress greater than the 25 kg/cm^2 computed, but the increase is the same percentage for the whole set of fibres.

After the tapering end of each fibre was cut off, each test specimen had a reasonably constant section area throughout its length as attested by the fact that rupture always occurred at a measurable distance from the ends. To eliminate danger of yield, copper-foil tabs were used on both ends of the fibre.

Because of the variation of section area (Table I) from fibre to fibre it was necessary to adjust the loading weights to values different for each fibre. At first the adjustment of so many different weights promised to be a tedious chore. A moment's thought, however, led to the following rapid procedure: Knowing the accurately determined weight per unit length of the brass rod from which the weights were made, final adjustment to $\pm 1\%$

TABLE I

Fibre No.	Nominal % R. H. of test	Section Area $mm^2 \times 10^{-4}$	Initial Length Lo mm	Load for stress of 25 kg/mm²
0	0	1.20	22.0	2.97
1	10	1.06	18.0	2.64
2	20	2.20	23.0	5.50
3	30	1.29	22.2	3.21
4	40	1.16	24.5	2.90
5	50	1.30	22.2	3.24
6	60	0.99	22.1	2.47
7	70	1.39	24.0	3.48
8	80	0.85	23.0	2.12
9	90	0.67	22.7	1.67
10	100	1.29	20.7	3.20

of the indicated value can be made in one cut on a lathe provided with a graduated slide. The weights were previously provided with the mounting hook and were made purposely heavy so that final adjustment is made by removal of metal. A series of eleven fibres, one for each relative humidity from 0 to 100% in nominal steps of 10% were prepared and measured (see Table I). The fibres were taken from a sample of 1 3/16″ middling Delta American cotton, crop of 1935–36.* This grade of cotton is used in fairly fine goods and where considerable strength is essential, such as is demanded in the manufacture of tire cords.

Results

Experience with the synthetic fibres indicated that if a fibre supports a given stress at 90% or 100% R. H. for a few minutes it will support the same stress at lower R. H. for a longer time. Preliminary tests at 100% and 90% indicated that the 25 kg/mm² stress would not be excessive. This rule, however, is not strictly valid for Delta cotton. Above 60% R. H. there was measurable creep with rupture after varying times as indicated in Fig. 1. Contrary to expectations, in all filaments tested below 50% R. H. rupture was instantaneous. The filaments were brittle.

It is reasonable to relate the brittleness to the relatively low creep rate (Fig. 1), and the absence of plastic flow as revealed by the cotton stress-strain relation.[3] At the instant a tensile load is applied, the stress distribution is not absolutely uniform throughout the whole fibre. In the neighborhood of cracks and pits on the surface, or in the interior of the fibre material, local stresses are set up which may greatly exceed the average stress given by the load-to-section ratio. This is the so-called stress concentration phenomenon so familiar to engineers. Local rupture will occur at the points of high stress unless the material yields in one of three ways: by elastic strain, by creep, or by plastic yield. The last is the large extension at high stress which results in permanent set. Yield at points of stress concentration automatically throws more of the burden of supporting the

* Obtained by courtesy of P. M. Strang, Auburndale, Mass.

tension on other regions, increasing their stress and smoothing out all stress irregularities toward a uniform average value. If there is no yield, or if the rate of yield is too slow to keep up with the rate of loading, local rupture occurs and progresses rapidly across the specimen. The relation between rupture tendency and rate of yield is well illustrated by pitch-like substances where rapidly applied stresses, *e.g.*, a blow from a hammer, will cause brittle fracture; while if the stress is applied sufficiently slowly rupture may be entirely avoided.

In the acetate and cuprammonium filaments there is a fairly definite relation between the creep at the end of the arbitrarily chosen time interval

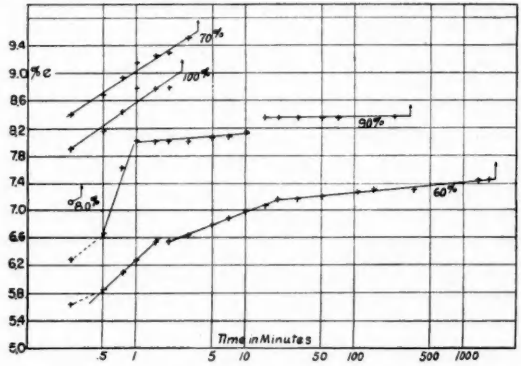

FIG. 1.—Creep in Middling Delta cotton single fibres at a tensile stress of 25 kg/mm². Fibres not previously stressed. Five fibres of the set of eleven listed in Table 1 which did not exhibit brittle rupture.

of 3′ and the R. H. (see Fig. 6 [1] and Fig. 2 [2]). In both cases below 60% R. H. the creep is relatively small and constant. Near 60% R. H. the creep rises rapidly. Although no such plot can yet be made for cotton it is interesting to note that above 60% R. H. there is measurable creep at a stress of 25 kg/mm², while below 60% the fibres break instantly at this stress. The brittle breaking can of course be avoided by making the stress small enough.

In Figs. 1, 2 and 3 the percentage strain (e) is plotted against the logarithm of the time (t), with the frequent occurrence of curves made of linear segments just as in the case of the acetate filaments[1] and less certainly in the case of the cuprammonium[2] filaments. In the acetate filaments the slopes of the straight segments, in general, tend to higher values with increasing time, while with cotton the reverse is true. The straight line plots lead to the logarithmic relation

$$e = k \log t + c$$

between elongation (e) and time (t) which seems to be fundamental for cellulosic fibres.

The Egyptian cotton of Fig. 16,[3] had an elongation of 5.5% at 50% R. H. and a stress of 25 kg/mm². Compare this with the 5.6% (e) for the 60% R. H. curve of Fig. 1. This is good agreement considering the nature of the phenomena. We may conclude, at least to a first approximation, that the first point plotted in each of the creep figures (1, 2, 3) represents the elastic strain initiated by the sudden application of load, and we may define the percentage creep as the percent elongation at any time diminished by the elastic strain.

The curves of Fig. 1 represent the five fibres of the original series of eleven which did not break instantly. The longer half of each of the remaining six which reveals brittle rupture was remounted and retested for creep at the lower stress values in kg/mm² printed on the curves of Fig. 2.

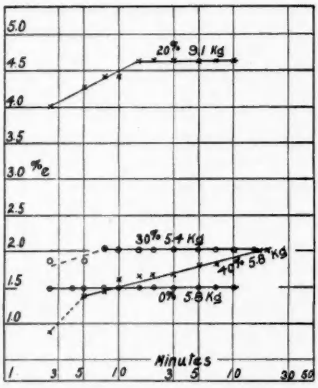

FIG. 2.—Creep in Middling Delta cotton single fibres at the several unit stresses and R. H. values indicated. The four fibres previously stressed to rupture at 25 kg/mm².

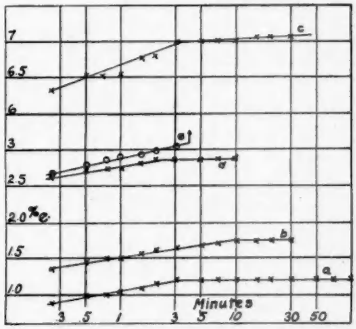

FIG. 3.—Creep in two separate single fibres of Middling Delta cotton. Curves (a) and (b) for one fibre, (c), (d), and (e) for the other.

The curves of Fig. 3 apply to two fibres of a preliminary test in which the section area was not determined. Curves (a) and (b) apply to the same fibre where (a) represents the results of a load of 0.7 g, or approximately 5.5 kg/mm², applied to the previously unstressed fibre. The same fibre was again stressed at 5.5 kg/mm² at 100% R. H. (curve b). Curves c, d and e apply to another fibre stressed three times in succession with a load of 2 g, or approximately a stress of 9 kg/mm². As one would expect, the first stressing curve (c) is higher than curve (d), the second stressing, both at 90% R. H. A third stressing with the same load, but at 100% R. H., finally resulted in rupture on curve (e).

The experiments described here lead to the general qualitative statements listed below. To search out the relations between the variables,

creep, R. H. and unit stress in quantitative detail would require the testing of many more fibres under varying conditions. Such an elaborate experimental program will have to wait a future date.

Summary of Results

1. At a stress of 25 kg/mm² Delta cotton is brittle and breaks instantly at relative humidities less than 50%. Above 50% creep of several percent precedes rupture.

2. Where creep does occur, it seems to follow the relation

$$e = k \log t + e$$

with several sudden changes in (k).

3. The straight segments of the creep curves have a general tendency toward lower slope with increasing time. The data, as far as they go for cuprammonium rayon above 60% R. H., also exhibit this tendency toward lower slope. The behavior of the acetate fibres is the reverse.

References

1. R. L. Steinberger. *Tex. Rsch., VI,* 4, 191–206 (1936).
2. *Ibid., VI,* 6, 267–9 (1936).
3. *Ibid., IV,* 5, 231 (1934).

Worth Cheering*

"Business men like to talk of the fruits of co-operation, but the practice is usually less enthusiastic. Trade associations have learned this; on their committees a few members do most of the hard work. In industrial research business has sometimes provided technical problems and then passed an important share of the work to some government laboratory.

"There is another way in which teamwork falls short of expectations. A recent illustration is brought to notice by the *American Dyestuff Reporter* in an article on textile research. Ultimately, the wearers of shirts or pajamas receive some benefits of any process that improves the cloth. The United States Institute for Textile Research, which is not a government agency, has been studying warp sizing; that is, the preliminary treatment of yarn or thread before weaving. The Textile Foundation subscribed half the amount required to pay for this research.

"'It seems reasonable to expect,' says the *Reporter,* 'that a large amount of useful basic knowledge will become available, and more extensive and diversified in nature than an individual organization could possibly produce for itself for many times the cost of participating in the results of the research.' But who paid the other half of the fund required? Of one group of twenty-five contributors eleven are chemical companies that make sizing materials; the others are textile manufacturers, including rayon makers.

* *Editorial from New York Sun, March 16, 1936.*

(*Continued to P. 339*)

An Optical Method for the Length Analysis of Cotton Fibres*

By K. L. HERTEL and M. G. ZERVIGON

Introduction

IN cotton breeding work and in many other studies it is highly desirable to know the distribution of fibre lengths in a cotton. The determination of this distribution involves proper sampling of the population in question and analysis of the sample into its component fibre lengths. The problem of sampling will not be considered here, except as it affects the problem of analysis. Baer, Suter-Webb,[1] Balls,[2] and others have developed methods and devices for analyzing a sample of cotton into its component fibre lengths. All of these methods involve fractionating the sample mechanically into length groups, then weighing or counting the fibres in each group. The results are plotted as length frequency curves, or more commonly as length-cumulative frequency curves. In any case the process is rather tedious, particularly because of inherent difficulties in the mechanical fractionation of the sample. The present paper describes a method of indirect analysis that eliminates the necessity for the mechanical separation of the fibres into length groups and does not require weighing or counting of the fibres to obtain the length-cumulative frequency curve.

I. The Optical Analysis

In order to simplify this discussion two assumptions will be made and their validity discussed later.

The first assumption has to do with the type of sample. It is assumed that the sample available for analysis is a bundle of straight, parallel fibres, and that all the fibres have their lower ends in a base plane b perpendicular to their directions. Since fibres of many lengths are included in the sample, it follows that the number of fibres in the cross-section of the bundle varies gradually from a maximum at b to zero at the apex. At any distance l from b the cross-section of the sample contains all the fibres longer than l.

The second assumption has to do with the properties of the fibres. It is assumed that in any one sample the color, fineness, opacity, and other similar properties of the fibres do not vary from one end of the sample to the other.

If a narrow beam of light scans the sample, some of the light flux will

* In substance, the contents of this paper were presented at the April, 1934 meeting of the Tennessee Academy of Science, Knoxville, Tennessee, under the title, "A Seed Cotton Fibrograph." A large part of the experimental data has been added since. The authors are associated with the University of Tennessee where Mr. Hertel is Head of the Department of Physics, and Mr. Zervigon is Associate Physicist.

be absorbed by the cotton. The amount of light flux transmitted will vary with the variations in the number of fibres in the path of the light and with variations in the color, fineness, opacity, and other properties of the fibres. But according to the second assumption these properties remain constant; therefore the variations in the transmitted light flux as the beam scans the sample from base to apex are due only to variations in the number of fibres in the cross-section of the sample. In other words, the amount of light flux transmitted is a function of the relative number of fibres only. According to the first assumption, at any distance l from b the cross-section contains all the fibres longer than l; therefore it should be possible to translate the amount of transmitted light flux into cumulative length-frequencies if the functional relationship between number of fibres and transmitted light flux is known. The instrument designed to accomplish this translation and plot the results semi-automatically has been called a "cotton fibrograph."

II. The Fibrograph

The fibrograph (Fig. 1) is essentially a null optical instrument with an electric indicator and suitable recording elements. The two balanced optical systems originate in the same light source L and terminate in photoelectric cells *A* and *B*. The cells are connected in series. A galvanometer *G*, in parallel with them, indicates when the differential current is zero; that is, when the optical systems are balanced. The light flux reaching *A* is that transmitted by the cotton sample *C*. The light flux reaching *B* may be controlled at will by moving cam *D*, which in conjunction with slit S_2 serves the function of an iris. As the cotton moves in front of scanning slit S_1 any variation in the number of fibres varies the amount of light flux reaching *A*. In order to maintain a balance, the cam *D* must be moved to produce the same variation in the light flux reaching *B*. The distance traveled by the cam is related to the change in number of fibres at S_1 through the shape of the cam itself. When the cam is properly shaped, the distance it travels is directly proportional to the change in number of fibres at S_1. On the other hand, the distance traveled by the cotton corresponds to a length of fibres, since the direction of the motion is parallel to the direction of the fibres. In other words, the motions of the cotton and the cam are proportional to length of fibres and number of fibres respectively, and are at right angles to each other. Therefore they correspond to the co-ordinates of the desired length-cumulative frequency curve. If recording elements are provided to plot the two motions, the length-cumulative frequency curve results. The recording elements consist of a pen *P* that moves integrally with the cotton, and a card plate *H* that moves integrally with the cam.

III. Operation

The operation of the fibrograph may be divided into two distinct steps. The first step is the preparation of the sample for analysis. The second is the analysis of the sample. These steps will be discussed separately.

1. *Preparation of the Sample:* According to the first assumption of Section I, the fibres of the sample should be straight and parallel, and their bases should be aligned in a plane. Such a sample may be approximated by combing the fibres on a seed into the familiar halo, then selecting a portion of the halo for analysis. The surface of the seed approximates the

base plane and parallelism may be approached by combing. A typical sample obtained in this manner is seven millimeters wide, contains approximately 1500 fibres, and weighs about three or four milligrams. It requires about five minutes for its preparation. The first fibrograph was designed specially for this kind of sample.

2. *Analysis of the Sample:* When the sample has been prepared, the operator clamps the seed in a detachable sample holder and places it in the fibrograph so that the scanning slit S_1, Fig. 1, is near to the seed. He ad-

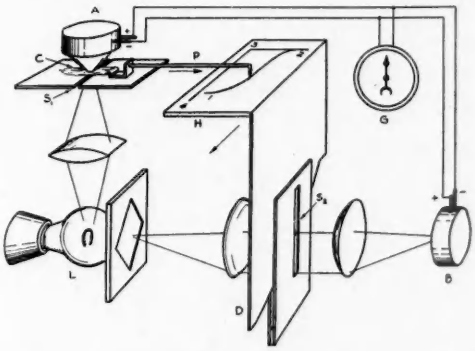

FIG. 1. Schematic diagram of the fibrograph.

justs the cam until the galvanometer indicates a balance, and releases the pen so that it rests on the card *H*. From this point the recording of the curve begins. With his left hand the operator turns a lead screw that advances the cotton and pen to the right. With his right hand he controls the positions of the cam and the plate so that the galvanometer indicates an approximate balance at all times. He moves both elements continuously and produces curve 1–2. At 2 all the cotton has been scanned and the cam remains stationary. At this point the operator runs the pen back against a stop and draws the axis 2–3 of fibre length. With the pen against the stop he moves the card up to draw the axis 3–4 of cumulative frequency. This completes the analysis. The average time required for one analysis is three minutes or less. Fig. 2 shows the fibrograph in operation.

IV. The Fibrogram

The record curve has been called a "seed-cotton fibrogram." It is intended as an approximation to a length-cumulative frequency curve. In other words, its ordinates should represent lengths of fibres, and its abscissae should represent relative number of fibres along a cumulative scale. The fibrogram ordinates do represent length of fibres, except for a constant correction that is usually necessary to account for the fact that the fibres are not completely straightened by combing. This has been called the "waviness" correction. In order that the abscissae represent relative

FIG. 2. Operating the fibrograph.

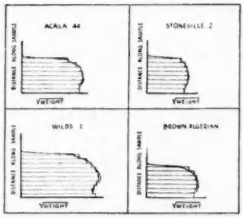

FIG. 4. Profile fibrograms vs. histograms of $\sqrt{\text{weight}}$.

number of fibres the two following requisites must be met: *first*, the balancing cam *D* must be calibrated correctly; and *second*, the second assumption of Section I relative to the properties of the fibres must be justified. The first requisite is controllable, but the second is not.

Calibration of the Balancing Cam: If the displacement of the cam necessary to balance a change in the number of fibres at S_1 (Fig. 1) is directly proportional to that change, the cam is shaped correctly. For narrow slits at S_1 and S_2 the shape of the cam is a graph of the light flux transmitted as a function of the number of fibres. Preliminary experiments indicated that the cam should be approximately exponential, but later it was found that corrections were necessary. These corrections were made empirically by actual calibration, as follows: A sample was prepared in the Suter-Webb sorter with fibres of approximately equal length. This sample was placed in the fibrograph, and the mean cam displacement from the position for zero fibres was measured. The number of fibres in the sample was reduced in successive steps of approximately 100 fibres each, and at each step the new mean displacement was measured and the fibres removed were counted. The total number of fibres in the sample at each step, plotted against the corresponding mean cam displacements constitute a calibration curve. From a number of these curves the corrections for the cam were calculated. Finally, the corrected cam produced the desired straight-line calibration curve (see Fig. 3). Calibrations were performed with cottons

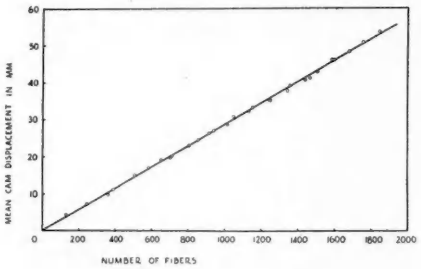

FIG. 3. Calibration curve.

varying widely in such properties as color and fineness, and in each case the calibration curve was practically a straight line, showing that those variables do not affect the calibration if they are uniformly distributed. The slopes of the different curves varied, but since the fibrogram scale of abscissae is in relative units, the variations in slope from curve to curve are immaterial.

An effort was made to establish a theoretical background for the shape of the cam. In solving a somewhat similar problem Silberstein[3] derived an equation for the light transmitted through turbid media in terms of the thickness of the medium and its optical properties. In a modified form his equation may be written $(2b/y) = (a + 1)\ e^{x} - (a - 1)\ e^{-x}$ where y may be interpreted as the amount of light transmitted, and x as the corresponding cam displacement. The parameter a is a function of the optical properties of the material. For simplicity an approximate value for a was determined indirectly from the empirical results available in the calibration data. The cam thus derived gave a straight-line calibration for about three-fourths of the range used. Evidently the conditions assumed in the Silberstein development are not exactly duplicated in the fibrograph. The theoretical development of the shape of the cam awaits further study.

Fibre Properties: According to the second assumption (Section I), the fibres in any one sample, as a group, do not vary in color, fineness, opacity or similar properties from one end of the sample to the other. Experience indicates that in most cases this assumption is approximately correct for all group properties except fineness. The fineness does show appreciable variations from the base to the apex of the fibres. The longitudinal projection of one fibre showing these variations has been called the "profile" of the fibre by Balls.[4] The profile varies from fibre to fibre, but these variations are not sufficiently at random to cancel out in a group. This is particularly true in the seed sample, where the fibres are closely related and their basal ends are aligned. The resultant group profile causes variations in the light transmitted through the sample which are superimposed on the variations due to the changes in the number of fibres.

In order to isolate the effect of profile on the fibrogram abscissae, samples were prepared on the Suter-Webb sorter from fibres of approximately equal length. In each sample, therefore, the number of fibres was constant from end to end, and consequently the variations in the abscissae of the fibrogram of each sample must be attributed to other variables. Fibrograms from four of these samples are shown in Fig. 4. They represent four cottons that differ appreciably in fibre properties. The same samples were carefully sheared in sections three millimeters long, and the sections were weighed. The square roots of the weights were plotted as histograms on the fibrograms of Fig. 4. These data indicate that the fibrogram abscissae follow rather closely the variations in the square root of the weight of the fibres. In other words, the fibrogram abscissae are approximately proportional to the square root of the linear density of the fibres. The linear density should vary as the cross-sectional area of the fibres, and the square root of the linear density should vary as the width or "equivalent diameter" of the fibres, therefore the fibrogram of the special one-length sample is an approximate picture of the group profile of the fibres in the sample. This suggests the use of the fibrograph in the study of these group profiles.

In an ordinary sample the fibrogram abscissa is a function of two variables; *viz.*, the number of fibres, and the square root of the linear density of the fibres. If the fibrogram is to be interpreted as a length-cumula-

tive frequency curve, the effect of profile must be considered a distortion or error. The magnitude and direction of this distortion will vary for different fibre profiles. However, since all fibres seem to taper toward their apex, there should be a general tendency for the fibres to appear shorter and less uniform in the fibrogram than they really are. The actual deviation of the fibrogram from a length-cumulative frequency curve remains to be measured. It will be treated in the remaining sections.

V. Data and Results

The most direct test of the ability of the fibrogram to represent the length distribution of a cotton is to compare the fibrogram of a sample with the actual length distribution of the same fibres as obtained by direct measurement. This type of test was made on 78 individual samples representing ten varieties. The procedure on each sample was as follows:

The fibres on each seed were combed into the familiar halo. Two samples were selected from each halo at diagonally opposite regions on the seed. Thus the fibres close to the apical end of the seed, as well as those close to the basal end, were represented. A fibrogram was made from each sample. The fibres were then carefully pulled from the seed, and each individual fibre stretched on a velvet pad and measured to the nearest millimeter. After the number of fibres had been cumulated, these data yielded the length-cumulative frequency curves for comparison with the fibrograms. Nine of these curves are compared with the corresponding fibrograms in Fig. 5. As was mentioned before, the fibres were not exactly straight when the fibrograms were made. For this reason the fibrogram ordinates were multiplied by a "waviness" factor of 1.15 before plotting. Actually this 15% correction is more than this waviness would warrant. This constant

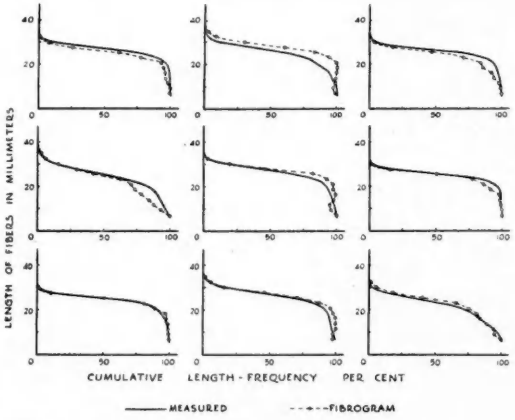

FIG. 5. Fibrograms compared with actual length-cumulative frequency curves. Individual seed samples of Triee cotton.

factor was determined from an experimental average and included also a correction for some of the shortening effect produced by the fibre profile. More work along this line will be necessary if these two effects are to be separated.

From inspection of Fig. 5 it becomes apparent that individual seed samples do not show good agreement consistently. The sources of these errors fall under three headings, as follows:

1. Fibre profile. This was discussed in Section IV.

2. Variation in waviness. The 15% correction is an average based on a large number of samples. Actually the waviness varies from sample to sample, so that some individual samples are overcorrected and some undercorrected.

3. Accidental errors. These are usually small and can be due to various types of irregularities in the sample. The most important cause is the mal-distribution of the fibres across the scanning slit. The instrument is calibrated for a uniform distribution and small errors are produced by bunching of the fibres into groups.

The second and third sources of error are random variations which should cancel out in the mean of a number of samples. Even the effect of profile should be reduced by combining several samples into one composite sample. This is shown in Fig. 6, where each variety is represented

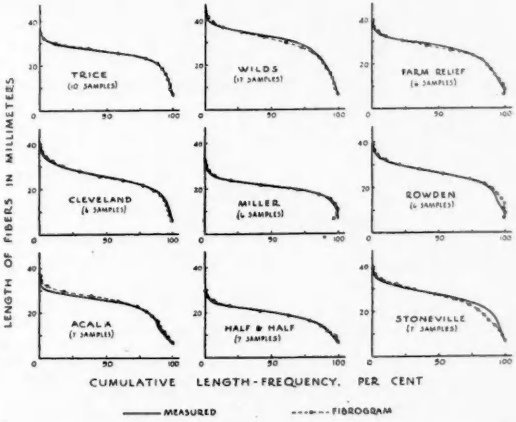

FIG. 6. Fibrograms compared with actual length-cumulative frequency curves. Composite curves from six or more individual seed samples (nine varieties).

by a composite curve of at least six individual samples. The agreement is better and more consistent. In these composite samples the most important source of error is the fibre profile. In most cases it tends to make the fibrogram appear less uniform than the true length distribution curve, as was indicated in Section IV.

VI. Conclusions

The optical method for the analysis of seed cotton samples as used in the fibrograph has many desirable features and advantages. As described here, however, the method leaves much to be desired, particularly if the sample itself is included in the discussion.

In recounting its advantages we may say that the method is fast. Only seven or eight minutes are required to prepare a seed sample and analyze it. The human equation has been practically eliminated from the process of analysis. The instrument itself is rugged and portable. It operates from any 110-volt outlet. It is a null instrument and therefore variations in the line voltage and the galvanometer calibration have a negligible effect on its operation. The calibration is very stable, for it is embodied in the shape of the metal cam. The record is compact and permanent. It is a continuous curve rather than a series of points, and the operator takes no readings in obtaining it. Drawing the co-ordinate axes with each curve saves the difficulty of aligning the record card and improves the accuracy. No special skill is required of the operator.

Three important difficulties encountered are the following:

First.—The fibre profile distorts the fibrogram from a true length distribution curve.

Second.—The human element is still important in the preparation of the sample. Care must be exercised in combing the fibres and in arranging them into a uniform sample.

Third.—The seed sample is inadequate. It is too small, as was shown by the fact that at least six fibrograms had to be combined to produce a good agreement with the true length distribution curve. The seed sample also limits the application of the method, for the cotton in the market is usually in the form of ginned lint.

The last two difficulties apply to the sample itself rather than to the optical method. The first difficulty—that is, the effect of profile—is peculiar to the optical analysis and is beyond complete control. Even this first difficulty, however, can be traced largely to the seed sample, for the effect of profile would be greatly reduced in a sample made up of fibres from more random sources, where individual changes would cancel out in the group profile. The general tendency of the fibres to taper toward their apical end would remain, but even the effect of this taper would be minimized if half the fibres had their apical end, rather than their basal end, in the base plane, as would be the case in a sample made up from loose individual fibres.

Some of the disadvantages of the seed sample can be circumvented by careful combing and by selecting diagonally opposite regions of the halo for analysis. Combining six or more fibrograms into one composite curve also eliminates errors, but this requires tedious computations and consumes much time. The same result could be accomplished in less time by clamping six seeds together in one composite sample, and obtaining one fibrogram directly from the six seeds. The best conditions cannot be approached, however, as long as the seed is used as a basis for sampling. The seed sample was adopted simply to take advantage of the attachment of the fibres to the surface of the seed and thus provide alignment of all the fibres. The next obvious modification would be to prepare an aligned sample from more random sources. Such a procedure would consume too much time to

be practical. There is still a third method of approach. A random sample might be analyzed optically without recourse to alignment. This would at once solve or, at least, minimize most of the difficulties; but it would introduce a new and very considerable problem, *viz.*, the interpretation of the fibrogram of such a sample in terms of the length distribution of the fibres. This last method has been followed, and some interesting developments have resulted. Some of the results were reported to the Tennessee Academy of Science at its meeting in April, 1934, and will be included in a later publication.

The writers take this opportunity to acknowledge their gratitude to Mr. Newman Hancock, who first suggested the problem, and who has offered many suggestions. He furnished the samples of cotton used in this investigation. They are indebted also to Director C. A. Mooers of the University of Tennessee Agricultural Experiment Station for the use of Adams and Purnell funds, to Mr. W. R. Woolrich of the Tennessee Valley Authority for use of C. W. A. funds, and to Dr. W. G. Pollard and Mr. C. S. Harrill for assistance in carrying out this investigation.

References

1. Webb, Robert W. "The Suter-Webb Cotton Fibre Duplex Sorter and the Resulting Method of Length Variability Measurements." *Proc. Am. Soc. Testing Materials*, Philadelphia, Pa., V. 32, Part II (1932).

2. Balls, W. Lawrence. "A Method for Measuring the Length of Cotton Hairs." Handbook of the Sledge Sorter. Macmillan, London. 1921.

3. Silberstein, Ludwig. "Transparency of Turbid Media." *Phil. Mag., IV*, 1291 (1927).

4. Balls, W. Lawrence. "Studies of Quality in Cotton." P. 20. Macmillan, London. 1928.

(*Continued from P. 330*)

A later list of new institute members showed the same inadequate support on the part of textile mills.

"The millions of persons who have no reason to take sides in this discussion of where the money should come from will not be excited about it. But an opportunity is offered which lately has been rare, namely, the opportunity to cheer a large industry for a spirit of independence and self-help thus brought to light. A government bureau is not expected to conduct the study of sizing, nor is a government relief agency expected to put up the money. The main question is simply one of encouraging better teamwork within the industry. Cheer once more. Other problems in other fields could be solved in such a self-critical spirit."

Abstracts

This section is compiled under the direction of the Committee on Abstracts and Bibliography: Prof. E. R. Schwarz, Chairman, M. W. Weiss, Dr. Irving J. Saxl and C. H. Clark.

I. Fibres (Synthetic and Natural) and Fibre Analysis

Cellulose: Structure. S. Bezzi. *Chimica e Ind.*, 1935, V. 17, P. 406–15.

The author traces the development of theories of the structure of cellulose and similar products of high molecular weight, and studies in particular the work of Staudinger and its importance for science and industry. (From *J. T. I.*, Dec. 1935, P. A648.) (C)

Cellulosic Membranes: Transmission of Water Vapor Through. Harold Levey. *Plastic Products*, 1934, V. 11, P. 52–3.

The amount of water vapor transmitted from an atmosphere of 100 to 50% relative humidity at 70° F. was determined for papers, regenerated cellulose and cellulose esters and ethers. The maximum transmission was obtained for regenerated cellulose, and the minimum was obtained for the esters and ethers. (From *Paper Trade J.*, Sept. 12, 1935.) (C)

Chemistry of Wool Washing. B. Shtutzer. *Sherstyanoe Delo*, 1935, No. 1, P. 14–20; No. 2–3, P. 17–23; *C. A.*, 1935, V. 29, Col. 8344. (W)

Cotton Fibre: Effects of Certain Soil Types, Seasonal Conditions and Fertilizer Treatments on Length and Strength of. O. A. Pope. Ark. Agr. Expt. Sta., *Bull.* 319, 1935, 98 pp.

Statistical study of replicated field expts. (From *C. A.*, 1935, V. 29, Col. 8207.) (W)

Cotton Hairs: Hair Abnormalities and Density of Mass in the Boll. W. K. Farr. *Contr. Boyce Thompson Inst.*, 1934, V. 6, P. 471–8.

It is suggested that the density of the hair mass within the boll during the later stages of development is one of the important factors in the determination of the number of hair abnormalities. Cell enlargement and the formation of a thick cell membrane are two of the more conspicuous phases of cotton hair growth. The tendency to enlarge in an approximately linear direction is inherent. If obstructed in one region of the boll

cavity, however, the portion of the hair concerned apparently apropriates any available space in the immediate vicinity for enlargement. This may result in change in diameter, change in direction of growth, or any other of the many different types of abnormalities. The need for such adaptation upon the part of a single hair and consequently the probability of abnormality formation will be greater with increasing density of the hair mass. (From *J. T. I.*, June, 1935, P. A283.) (C)

FELTING PHENOMENON: THEORY OF. R. Brauckmeyer. *Deut. Wollen-Gewerbe*, 66, *Erfahr. u. Forsch.*, 1934, V. 1, P. 38–9; 1935, V. 1, P. 45–8; V. 2, P. 49–52.

Wool fibre differs from all other fibres in its chem. compn. as a horny material and in its exterior structure with a scale-like surface. The compn. of the wool is responsible for its high stretch and elasticity, low heat cond., good resistance to acids and the property of simple fast dyeing with dyes from various types, while the exterior structure is responsible for its fulling and felting properties. A no. of incorrect theories on the felting of wool are discussed and errors in the Witt theory are pointed out. A new theory is discussed: During the felting process there occurs a decided displacement of the position of the fibres, the fibres moving away from the yarn. The migration begins with the roots. Simple expts. are described and photographs are shown for demonstrating the correctness of the theory. The new felting theory is used to explain in detail the behavior of the wool during actual felting operations. Applications dealing with the use of soap in felting operations, artificial wool, chlorinated wool and rayon are discussed. (From *C. A.*, 1935, V. 29, Col. 8342.) (W)

FIBRES: ULTRA-MICROSCOPIC STUDY. A. T. Clifford and F. K. Cameron. *Rayon & Mell. Tex. Mo.*, 1935, V. 16, P. 290–1, 455–7.

Photo-micrographs, using the Spierer lens, are presented for various kinds of cellulose and other fibres. The striae observed are not due to the cellular micelles, as certain investigators have held, but are probably diffraction bands. The nature of the Spierer ultra-microscope is described. (From *J. T. I.*, Dec. 1935, P. A636.) (C)

ISOELECTRIC POINT OF WOOL. M. Déribéré. *Rev. Text.*, 1935, V. 33, P. 557.

A short review of the literature on the isoelectric point of wool. In 1933 and 1934 the following values were given—Götte and Kling, 5.8; Elöd, 4.9 and 5.1; Skinkle, 3.2–3.6; Boutin, 3.9; Déribéré, 4.6. (From *J. T. I.*, Dec. 1935, P. A606.) (C)

KERATIN MOLECULE: X-RAY STRUCTURE. W. T. Astbury and W. A. Sisson. *Proc. Roy. Soc.*, 1935, V. A150, P. 533–51.

X-ray examination shows that when keratin fibres are squeezed laterally in the presence of steam or water vapour, they are first transformed into β-keratin, and then the β-keratin crystallites rotate about their long axes in order to bring the protein side-chains normal to the plane of flattening. The biological cells in keratinous structures (hair, horn, etc.) are in general flat and laid down with their flat sides roughly parallel to the

natural surface of the specimen. The mechanism of the evolution of fibrous proteins is discussed with reference to recent X-ray results in the examination of pepsin, feather keratin and other proteins. (From *J. T. I.*, Oct. 1935, P. A539.) (C)

II. Yarns and Fabrics

Electrically Charged Rayon: Effects and Prevention. A. E. Cater. *Tex. Mfr.*, 1935, V. 61, P. 277–8, 313–4, 361–2, 368.

The generation of static electricity in textile processes is discussed and its effects in the warping and weaving of rayons, in the processing of rayon fabrics and in the spinning of staple fibre are described. Methods of prevention are reviewed. (From *J. T. I.*, Dec. 1935, P. A617.) (C)

Fast Finishing Methods. P. Krais. *Spinner u. Weber*, 1934, V. 52, No. 45, P. 8–10.

A review of three com. processes. (From *C. A.*, 1935, V. 29, Col. 8339.) (W)

Finishing of Rayon Fabrics. Samuel Bergneon. *Tex. Col.*, July, 1935, P. 449. (C)

Fish Net Preservatives. I. Preservatives Mixed with an Antiseptic Metallic Compound. II–III. Oily Preservatives Mixed with Copper Compounds. Masao Murata. *J. Soc. Chem. Ind., Japan* 38, Suppl. binding, 1935, P. 425–7; *C. A.* 1935, V. 29, Col. 8346. (W)

Geometrical Basis of Pattern Design. II. Nets and Sateens. H. J. Woods. *J. T. I.*, Oct. 1935, P. T293. (C)

Hygroscopicity: Practical Experiences with the—of Textiles in Textile Plants. M. Loescher. *Deut. Wollen-Gewerbe*, 1934, V. 66, P. 619–20.

A review. Raw wool may increase as much as 20% by wt. during storage due to absorption of moisture. L. advises the regulation of the temp. of the air. (From *C. A.*, 1935, V. 29, Col. 8343.) (W)

Mercerized Cotton Yarns: Lustre. F. Kurtz. *Leipz. Monats. Text. Ind.*, 1935, V. 51, P. 219–22.

Lustre measurements were made and the results are tabulated and discussed. (From *J. T. I.*, Dec. 1935, P. A638.) (C)

Moistening Textile Fabrics. H. Stenger. *Deut. Wollen-Gewerbe*, 1934, V. 66, P. 743–4.

The machine described is constructed with the thought of (1) imitating in this machine the natural absorption of moisture due to the hygroscopicity of fibres which occurs during the storage in cold rooms and (2) intensifying this process so as to bring about in a few mins. what other-

wise would require several weeks. The machine is manufd. by Maschinenfabrik M. Rudolf Jahr at Gera. The goods can never be overmoistened. (From *C. A.*, 1935, V. 29, Col. 8229.) (W)

NATURAL WOOL DAMAGE AND ITS CONSEQUENCES IN THE FINISHING PROCESSES. W. Zizka. *Wollen- u. Leinen-Ind.*, 1935, V. 55, P. 195–6; *J. T. I.*, Oct. 1935, P. A482. (C)

NON-TENDERING FIREPROOFING AGENTS. H. J. Henk. *Leipz. Monats. Tex. Ind.*, 1935, V. 50, P. 223–4.

The requirements of a fireproofing agent for textiles are outlined and the disadvantages of the usual materials are pointed out. The chief disadvantage of Al, Zn and Mg salts is that they decompose on exposure to air and heat, liberating mineral acids that cause tendering. Stable fireproof finishes that do not attack fibres or dyes can be obtained with sodium tungstate, vanadate or stannate, titanic acid, or ammonium bromide. The methods of application are outlined. (From *J. T. I.*, Dec. 1935, P. A630.) (C)

RAYON: "ACID NUMBER." M. Lüdtke. *Angew. Chem.*, 1935, V. 48, P. 650–1.

The calcium acetate method for the determination of the "acid number" of rayons is briefly described. (From *J. T. I.*, Dec. 1935, P. A637.) (C)

RAYON ANTI-STATIC DRESSING AGENT: APPLICATION. British Celanese Ltd. (London). E. P. 433,110 of 29/10/1934 (Conv. 27/10/1933).

A process for the treatment of filaments or yarns comprises applying thereto an anti-static dressing, and spraying the dressed filaments or yarns with a coating of lubricant. The lubricant is preferably sprayed on to the filaments or yarns by means of an air stream conveying the filaments to a staple fibre cutting device. The anti-static dressing may be applied in a controlled quantity by one or more wicks, fabric-covered rollers, grooved or plain rollers, or discs dipping into a solution or molten bath of the material. Suitable anti-static dressings are 100/30/6, 7 or 10 of diethylene glycol/water/magnesium chloride, or triethanolamine oleate, triethanolamine stearate with a trace of free triethanolamine. The anti-static dressing is applied in amounts of 2–10% of the filaments. Suitable lubricants include light mineral oil, olive oil, glycols, glycerol and formals. About 0.2–2% of lubricant is applied to the filaments. Lubricants which themselves have anti-static properties are fatty acids which are ionized in oils or organic solvents, emulsions of oil, water and substances such an triethanolamine lactate, tartrate, citrate or borate, or similar salts of ethylene diamine and similar amines or solutions of alkylolamine salts of fatty acids such as oleic acid in glycols or other polyhydric alcohols. The invention is particularly applicable to yarns of cellulose or its derivatives, to straws or foils, or to filaments which are to be wrapped round wires as an insulating covering. Suitable apparatus for forming staple fibres from filaments treated according to the invention is described. (From *J. T. I.*, Dec. 1935, P. A616.) (C)

III. Chemical and Other Processing (Not Otherwise Classified)

Dyes: Light Fastness Classification. C. M. Whittaker. *J. Soc. Dyers & Col.*, 1935, V. 51, P. 312–4.

The necessity is stressed for stating the minimum percentage of the dye claimed as equal in fastness to light to the standard pattern. Atmospheric exposure of 70 of the fastest-to-light direct cotton dyes on rayon and cotton yarns has revealed that there is no direct cotton black, grey, blue or green equal in light fastness to the fastest-to-light direct cotton reds, oranges or yellows. This is of significance in the blending of compound dyes. (From *J. T. I.*, Dec. 1935, P. A640.) (C)

Dyestuffs: Variations in the Dispersion of. C. Hanut and J. Fautrez. *Protoplasma*, 1935, V. 23, P. 93–108; *C. A.*, 1935, V. 29, Col. 8335. (W)

Electrometric Analysis of Mordanting Baths for the Textile Industry. L. I. Belen'kii and I. I. Sokolov. *Za Rekon. Tekstil. Prom.*, 1934, V. 13, No. 11, P. 35–40; *Chim. & Ind.*, V. 34, P. 415.

A study was made of the electrometric detn., by means of the glass electrode, of the pH of Cr, Fe and Al mordanting baths. (From *C. A.*, 1935, V. 29, Col. 7662.) (W)

Emulsions: Making of. J. S. Brown. *Tex. Mfr.*, 1935, V. 61, P. 383–4, 515.

A simple scheme is outlined for working out emulsions for tests and works expts., with notes on textile emulsions in general. (From *C. A.*, 1935, V. 29, Col. 7526.) (W)

Emulsions: Technical Aspects. Papers read at a symposium held in London under the auspices of the British Section of the International Society of Leather Trades' Chemists. Published for the Section by A. Harvey, London, 150 pp., price 5s. 6d. *J. T. I.*, Sept. 1935, P. P342. (C)

Fibre: Action of Boiling Caustic Soda (Kier Boiling) on Insoluble Azo Colors on the. III. Coloring Matters Derived from Arylamides of β-hydroxynaphthoic Acid and Containing a Nitro Group or Groups. F. M. Rowe and C. H. Giles. *J. Soc. Dyers Col.*, 1935, V. 51, P. 278–83; cf *C. A.*, V. 26, P. 2322; 1935, V. 29, Col. 6761. (W)

Heat Economy During the Bleaching of Textiles. Otto T. Koritnig. *Deut. Wollen-Gewerbe*, 1934, V. 66, P. 413–5.

A detailed discussion with numerical examples illustrating the extent of the saving of coal obtainable by the heat isolation of bucking kiers and the side walls of drying machines. (From *C. A.*, 1935, V. 29, Col. 8340.) (W)

HOSE-DYEING MACHINE: NEW. Frank Christian. *Dyer*, 1935, V. 74, P. 257–8.

The machine consists essentially of six dyeing cylinders attached radially round the circumference of, and connected to, a large central cylinder, which can be rotated horizontally round its central axis. The chief advantage is the unprecedented speed of dyeing. (From *C. A.*, 1935, V. 29, Col. 7662.) (W)

IMPREGNATION METHODS: MODERN. A. Foulon. *Deut. Wollen-Gewerbe*, 1934, V. 66. P. 997–8.

A review of the processes of water-tight and water-repelling impregnations as applied to the textile industry. (From *C. A.*, 1935, V. 29, Col. 8339.) (W)

MERCERIZING: EFFECT OF—ON THE TENSILE STRENGTH, LENGTH AND SIZE OF COTTON YARN. Kurt Langer. *Melliand Textilber.*, 1935, V. 16, P. 507–8; cf. *C. A.*, 1934, V. 28, Col. 3910; 1935, V. 29, Col. 7082. (W)

NAPHTHOL AS DYEINGS: HOW TO IMPROVE THE RESISTANCE OF RUBBING TO. H. Korb. *Monatschr. Textil-Ind.*, 1935, V. 50, P. 171; *C. A.*, 1935, V. 29, Col. 6762. (W)

OILS: SOME NOTES ON—FOR PROTECTION OF RAYON, SILK AND WOOL. C. H. S. Tupholme. *Tex. Col.*, 1935, V. 57, P. 247, 274.

The need for oils, their selection and application are considered. (From *C. A.*, 1935, V. 29, Col. 6766.) (W)

pH INDICATORS. Chas. E. Mullin and Elizabeth Aughey. *Tex. Col.*, 1935, Aug., P. 518; Sept., P. 589; Oct., P. 668; Nov., P. 736; Dec., P. 809.

A tabulation of the colorimetric indicators that may be suitable for the determination of hydrogen ion concentration. (C)

PRINTING OF CLOTHS BY AIR-BRUSH SPRAYING. M. M. Kissileff. *Rev. gen. mat. color.*, 1935, V. 39, P. 265–70, 305–12.

Various types of apparatus are described, as well as the manner of use of various types of dyestuffs on cloths of various fibres. (From *C. A.*, 1935, V. 29, Col. 7662.) (W)

RAYON STAPLE FIBRE FABRICS: DYEING AND FINISHING. *Leipz. Monats. Tex. Ind.*, 1935, V. 50, *Fachheft* I, P. 5–7.

Difficulties experienced in the processing of goods containing rayon staple fibre in combination with wool, cotton or other textiles are discussed and it is pointed out that these difficulties can frequently be overcome by the use of suitable wetting agents and asssitants. (From *J. T. I.*, June, 1935, P. A304.) (C)

RAYONS: BEHAVIOR OF—IN THE PRESENCE OF BLEACHING LIQUORS. H. Russina. *Monatschr. Textil-Ind.* Trade Issue II, 1935, V. 50, P. 60–2; *C. A.*, 1935, V. 29, Col. 7665. (W)

RUBBING: LACK OF FASTNESS OF CLOTH TO. Karl Stirm. *Deut. Wollen-Gewerbe* 66, *Erfahr. u. Forsch.*, 1934, V. 1, P. 9–10.

Dark-colored cloth (black, blue and bluish mixts.) turned white in those spots which were exposed to rubbing during wear. This defect was due neither to faulty dyeing nor to the presence of free or lime soap. The white spots were caused by an optical phenomenon. The mechanically destroyed wool hairs, down to the longitudinal fibrils of the inner wool keratin C which are not present in cloth fast to rubbing, reflect light differently from normal, healthy and undamaged wool hairs. The results of microscopic studies show that the phenomena of lack of fastness to rubbing and the occurrence of mold spots are due to the same cause and that there is only a quant. and not a qual. difference between them. The fastness to rubbing can, therefore, be increased by a careful control of all plant operations with the view of avoiding all factors favoring the growth of bacteria. (From *C. A.*, 1935, V. 29, Col. 8341.) (W)

SILK: DYEING. E. Elöd. *Textilber.*, 1935, V. 16, P. 201–4.

Investigations of the dyeing of loaded and unloaded silk with substantive dyes are described. Data showing the influence of pH and of salt additions are given. (From *J. T. I.*, July 1935, P. A351.) (C)

IV. RESEARCH METHODS AND APPARATUS

FALLING SPHERE VISCOMETER OPTICAL RECORDING DEVICE. M. W. Ghali. *C. r. Acad. Sci.*, 1935, V. 200, P. 2155–7; *J. T. I.*, Sept. 1935, P. A471. (C)

FIBRE: DETERMINATION OF THE FINENESS OF THE—ACCORDING TO THE WEIGHING METHOD. H. Fischer. *Deut. Wollen-Gewerbe*, 1934, V. 67, P. 240, 242, 537–40.

An app. is shown and described by means of which it is possible to calc. the fineness of any textile fibre from detns. of its wt. and length. Detailed directions are given for employing this app. for detg. the av. fibre length and av. fibre fineness either separately or together. Math. formulas are developed for making all necessary calcns. The max. error by this method is $\pm 2\%$ which is smaller than that obtainable with any microscopic method. This method is, therefore, usable in industrial plants as well as in labs. Other procedures are described for judging the spinning values of textile fibres and which are based upon the weighing method. (From *C. A.*, 1935, V. 29, Col. 8340.) (W)

GELATIN AND GLYCEROL: VISCO-ELASTICITY MODULUS. E. Madelung and S. Flügge. *Ann. Physik*, 1935, V. 22, P. 209–22.

Substances such as gels, possessing properties both of elasticity and viscosity, can be described by means of a complex modulus of elasticity. The elasticity and the viscosity form the real and the imaginary components respectively of a single coefficient (analogous to the complex optical refractive index). This modulus is dependent on the frequency so that the problem can be treated as a dispersion of elastic waves. A method of

measurement of this complex elasticity is described. Results are given for gelatin and glycerol. (From *J. T. I.*, June, 1935, P. A328.) (C)

HYDROGEN ION CONCENTRATION: DETERMINING. Dr. N. Gerbers Co. (Leipsic) E. P. 429,906 of Feb. 9, 1933.

The hydrogen ion concentration of a substance is determined by comparing it electrometrically or colorimetrically with a solution of known hydrogen ion concentration, and titrating the latter solution with alkali until it corresponds to the liquid under test. (From *J. T. I.*, Sept. 1935, P. A478.) (C)

MEASUREMENT OF THE AIR PERMEABILITY OF FABRICS. F. C. Clayton. *J. T. I.*, June, 1935, P. T171–86.

Describes a method of measuring air permeability of fabrics that has been in use at Shirley Institute for some years, and has been applied to a wide variety of problems. This method is described in sufficient detail to serve as instructions for the construction and use of the instrument, and some examples are given to illustrate the applications of the test. By this method, the air permeability is determined in well-defined units with speed, convenience, and accuracy. (C)

MEASUREMENT OF pH ELECTROMETRICALLY. Pegasus. *Tex. Col.*, April, 1935, P. 227. (C)

MECHANICAL TESTING OF THE SUITABILITY OF FABRICS FOR SHOE LININGS. R. S. Edwards. *J. T. I.*, July, 1935, P. T211–25. (C)

MOISTURE PERMEABILITY TESTING APPARATUS. W. Staedel. *Leipz. Monats. Text. Ind.*, 1935, V. 50, P. 146–8, 168; *J. T. I.*, Oct. 1935, P. A525. (C)

OLEINS IN THE TEXTILE INDUSTRY. Kehren. *Deut. Wollen-Gewerbe*, 1934, V. 66, P. 1271–4; cf. *C. A.*, 1934, V. 28, Col. 7022; 1935, V. 29, Col. 8342.

K. considers the Mackey test a sure indication of the oxidizability and hence the inflammability of oleins. Detailed directions are given for carrying out the Mackey test. (W)

pH VALUES: CALCULATION OF. W. R. Atkin and F. C. Thompson. *J. Internat. Soc. Leather Tr. Chem.*, 1935, V. 19, P. 140–7.

The approximate form of the mass-law expression for the dissociation of a weak acid, $h^2 = \text{K.C.}$ is used as a basis for calculating the pH values of solutions of acids, bases, and salts at varying concentrations. (From *J. T. I.*, June, 1935, P. A329.) (C)

PRECISE DETERMINATION OF DENIERAGE IN SHORT YARN LENGTHS. Dr. I. J. Saxl. *Tex. Col.*, Nov. 1935, P. 776.

Describes an apparatus for making a 90 cm. test, and the advantages of such a test. (C)

V. Economics, Physics and Miscellany

Potato Starch: Sedimentation Velocity and Sediment Volume. Influence of pH. E. Wiegel. *Kolloid Z.*, 1935, V. 71, P. 65–73; *J. T. I.*, Sept. 1935, P. A475. (C)

Protein Nitrogen: Determination of. Accelerating the Kjeldahl-Gunning-Arnold Digestion by Addition of Phosphates. H. S. Gerritz and J. L. St. John. *Ind. & Eng. Chem., Anal. Ed.*, Nov. 15, 1935, P. 380. (X)

Rupture of Plastic Crystals. E. Orowan. International Conference on Physics, London, 1934, Vol. II. Solid State of Matter, P. 81–92.

Rupture starts from nuclei. These are cracks which may develop by plastic slip and an explanation of practical tensile strength becomes possible, but it is suggested that a secondary block structure is not capable of explaining the observed facts. (From *Science Abs.*, Sept. 1935, Col. 3280.) (X)

Book Reviews

Färberei- und textil-chemische Untersuchungen. Dr. Paul Heermann. 6th Edition. Pp. 407. Berlin: Verlag von Julius Springer, 1935. Price, cloth, Germany, 16.87 Rm.; other countries, 22.5 Rm.

Prof. Heermann's well-known work on the methods of investigation used in dyeing and textile chemistry, first published in 1898, has now reached its sixth edition, which has been largely revised and rewritten to cover the progress made in these subjects in recent years. The matter has not only been brought up to date, but the book is actually slightly shorter than the last edition, as a result of the deletion of early methods, etc., the inclusion of which is no longer necessary. (From *J. Soc. Dyers Col.*, Dec. 1935, P. 420.) (C)

Cotton Research in India, 1924–1935. Nazir Ahmad, Director, Technological Laboratory of the Indian Central Cotton Committee, Matunga, Bombay. Pp. 100. Price, Rs. 2–0–0.

In the book under review Director Ahmad not only provides very complete and carefully interpreted abstracts of the researches on the cotton fibre (largely Indian) and yarn conducted under Dr. A. J. Turner from 1924 until Dec. 1930, and under Mr. Ahmad since then, but provides a condensed summary and a complete index. The latter also gives the date of publication and price of each of nearly 300 bulletins and circulars. The volume is illustrated with views of the exteriors and interiors of the research and the spinning laboratories, handsome and well-equipped buildings that cost 5 lakhs of rupees, and that would cost in this country around $250,000. The Indian Central Cotton Committee which administers these laboratories is a government body, and the laboratories collaborate with the Provincial Agricultural Departments, and also serve cotton breeders and the East Indian Cotton Association and the millowners' associations of Bombay and Ahmedabad. (C)